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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 118.
L. O. HOWARD, Entomologist and Chief of Bureau.

THE BEAN THRIPS.

BY

H. M. RUSSELL,
Entomological Assistant.

ISSUED OCTOBER 16, 1912.

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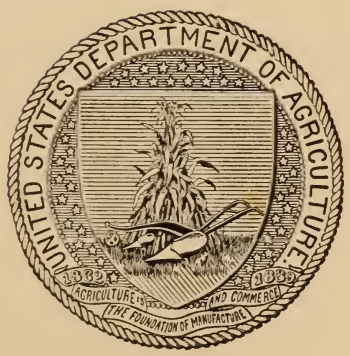

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 24, 1912.

Sir: I have the honor to transmit herewith for publication a manuscript entitled "The Bean Thrips," by H. M. Russell, an entomological assistant of this bureau.

This bulletin deals with an insect pest of the family Thripidæ, the study of which has been hitherto largely neglected, and which of recent years has attracted considerable attention from an economic standpoint, as the cause of immense losses in the Pacific coast regions and elsewhere to truck farmers. The insect is closely related to the tobacco thrips, as well as to the onion thrips, to which species are chargeable untold losses in the production of these two staples. Experiments to produce formulæ and devices with which successfully to combat this insect are being perfected, and methods for the complete control of the pest are early expected.

I recommend the publication of this manuscript as Bulletin No. 118 of this bureau.

Respectfully,

L. O. Howard,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE BEAN THRIPS.

(*Heliothrips fasciatus* Pergande.)

INTRODUCTION.

In the State of California during the past four or five years the bean thrips has been reported with increasing frequency as a serious pest to various crops. The common name " bean thrips " is somewhat of a misnomer, as this insect feeds on many different crops, but is retained here, as it is well known by that name in California. That State, with its long, dry summer, furnishes climatic conditions unusually favorable to the development of thrips, and several species have gained such a foothold there as annually to cause a loss of hundreds of thousands of dollars.

In the summer of 1909, Mr. R. S. Woglum, of the Bureau of Entomology, informed the author that during the summer before he had seen hundreds of acres of beans in southern California so seriously infested by the bean thrips that they had the appearance of plants scorched by fire; and as this thrips seemed to be increasing in numbers and destructiveness it appeared to be the part of wisdom to obtain all possible information concerning its life history and control before it reached the enormous abundance of the destructive pear thrips (*Euthrips pyri* Daniel). When, therefore, the Bureau of Entomology established a field station at Compton, Cal., in September, 1909, for the study of truck-crop and sugar-beet insects, the writer planned, among other projects, to undertake as complete a study of this insect as time would permit. With this in mind, the bean thrips has been the subject of thorough investigation during the years 1910 and 1911. During this time, however, the insect was not again so destructive to beans, so that remedies with spray mixtures could not be thoroughly tested. Nevertheless, as the life history has been worked out and a large fund of information obtained on the distribution and habits of this thrips, together with knowledge of a natural enemy of some promise, this paper is published at the present time.

At Compton, in Los Angeles County, where the life history of this insect was studied by the writer, the temperature is quite cool, since the location is near the coast.

In the Imperial Valley the life history of the bean thrips and its injuries to alfalfa and cotton have been investigated by Mr. V. L. Wildermuth, of this bureau, and where his observations are used credit is given in the text.[1] Use has been made of observations, by Messrs. P. R. Jones and S. W. Foster, of this bureau, on this insect in the more northern points in the State. Since July, 1911, the writer has been ably assisted by Mr. John E. Graf. He also wishes to express his appreciation to Dr. F. H. Chittenden, under whose directions he has conducted the investigation, and to Prof. F. M. Webster for the free use of notes obtained by his agents.

NATURE AND EXTENT OF INJURY.

The damage caused by the bean thrips is not confined to the foliage, but affects as well the fruit and stems of the plant attacked. The injury is caused by the method of feeding. Both young and adults obtain their food by puncturing the leaf tissue with their sharp mouthparts and, after lacerating it, withdrawing the plant juices at the point of attack. Figure 1, although a drawing of a different species, gives an idea of the mouthparts of this insect.

FIG. 1.—Side view of the head of a thrips, showing the mouthparts. Much enlarged. (After Moulton.)

Each time as the contents of the leaf at the point attacked are removed, the thrips moves to a new point and repeats the operation, so that if the insects are abundant or the attack is long continued the leaf tissue is destroyed over the entire surface. As the supply on one side of the leaf is exhausted the larvæ move around to the other, or if adults are present these fly or jump to more tender leaves. The infested and badly injured leaves turn yellowish or white, dry up, and either drop off or hang lifeless to the plant. Then, as the attack continues, successive leaves are attacked until in extreme cases the entire plant is killed.

DESCRIPTION.

Heliothrips fasciatus belongs to the Suborder Terebrantia and the Family Thripidæ of the Order Thysanoptera, being placed in this position because of the downward-curved ovipositor of the female. The 8-segmented antennæ, with the last segment much longer than the 7th, and the reticulated surface of the body, together with the pointed spines on the wings, place this insect in the Genus *Helio-*

[1] Mr. Wildermuth studied the insect in its relation to alfalfa, without knowing that it was being investigated by the author. His studies, made under quite different climatic conditions, add materially to the value of the results obtained.

thrips. The habits of the larva are also quite characteristic of this genus, for the habits of the larvæ of the greenhouse thrips (*Heliothrips hæmorrhoidalis* Bouché) and of *Heliothrips rubrocinctus* Giard are almost identical with those of the present species.

THE ADULT FEMALE.

The adult female (fig. 2) is about one-twenty-fourth of an inch in length (0.9815 mm. to 1.1174 mm.; average, 1.0405 mm.) and about one-fourth as wide as long (0.2265 mm. to 0.2869 mm.; average

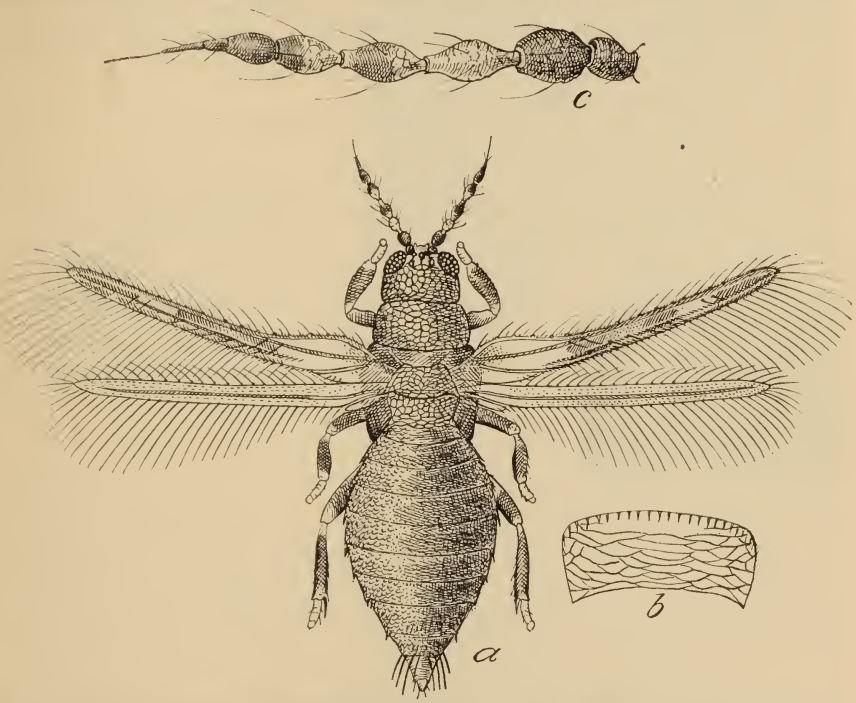

FIG. 2.—The bean thrips (*Heliothrips fasciatus*): *a*, Adult female; *b*, ventral side of abdominal segment of same; *c*, antenna of same. *a*, Greatly enlarged; *b*, *c*, more enlarged. (Original.)

width, 0.2529 mm.) and is fusiform in shape. The head and body are black and, under the microscope, are seen to be covered with distinct reticulations and short white hairs. The antennæ are 8-segmented and two and one-half times as long as the head, and are held out in front of the body. They are black, more or less banded with white, and bear white hairs. The wings are held folded together down the middle of the dorsum; they are black, crossed by a white band at the base and a white band at three-fourths the distance from the base. The wings are fringed with long white hairs. The legs are black, banded with white.[1]

[1] For a detailed description of the genus and the species for use of systematists, see Hinds's "Monograph of the Thysanoptera" (Proc. U. S. Nat. Mus., vol. 26, 1902), pp. 174–175.

THE ADULT MALE.

The male resembles to a great extent the female, as the color and the markings are the same, but it is noticeably smaller in size and apparently more active. When viewed under the microscope the sexual organs are seen to be distinctly different, and in light-colored or cleared specimens the testes may be seen as two orange-red bodies in the abdomen, and on the middle of each of segments 2 to 6 on the ventral side are yellowish oval spots. The total length of the male is 0.7097 mm. to 0.8002 mm.; the average, 0.7474 mm. The greatest width across the mesothorax is 0.1963 mm. to 0.2114 mm.; the average, 0.1978 mm.

RECENTLY EMERGED ADULTS.

Both sexes, when just emerged, have the head and thorax a light yellowish orange, with the eyes and ocelli bright red. The antennæ are white and ringed with brown, while the wings are dusky, crossed by bands of a darker color. The legs are white, with ends of each segment more or less black. Gradually the color darkens, and in a day they all have the fully matured colors, as described above.

FIG. 3.—The bean thrips: Eggs. Greatly enlarged. (Original.)

THE EGG.

The egg (fig. 3) is bean shaped, 0.21 to 0.255 mm. in length and 0.105 to 0.12 mm. in width, and is very delicate and thin shelled. It is translucent white, with a smooth shining surface. The eggs are laid in the tissue of the leaf or in the veins, or even in the stems, and in case of beans may be laid in the pods themselves. As the embryo within develops, the egg becomes swollen, and the little pocket in which it is inserted becomes raised above the leaf surface. The eggs may be seen in the leaf tissue if examined with a hand lens before the light. Each little egg pocket stands out, because of its lighter color, and within the crude outline of the egg may be seen.

The younger stages of this insect differ distinctly from those of *Heliothrips hæmorrhoidalis*[1] in the dashes of crimson so generally present on the sides.

THE FIRST-STAGE LARVA.[2]

(Fig. 4.)

Length, 0.42 mm.; width of mesothorax, 0.135 mm. General shape fusiform, similar to *Heliothrips hæmorrhoidalis;* head, antennæ, and legs large in propor-

[1] For description of *Heliothrips hæmorrhoidalis,* see "The Greenhouse Thrips," Bul. 64, Part VI, Bur. Ent., U. S. Dept. Agr., pp. 46–48, 1909.

[2] Description made while larva was very young and before feeding commenced.

tion to rest of the body. Color translucent white. Head large, quadrate; eyes reddish; ocelli absent. Antennæ 0.195 mm. in length, apparently 7-segmented; basal segment cylindrical, short; second nearly twice as long as first, barrel-shaped; third and fourth spindle-shaped, ringed with a few fine hairs; fifth, sixth, and seventh slender, nearly equal in length. Legs translucent white. Abdomen tapering posteriorly; first eight segments nearly equal in length, last two segments longer than others; each abdominal segment with longitudinal rows of setæ, the tenth with four setæ about 0.045 mm. in length.

At this stage there seems to be nothing to distinguish this species from *H. hæmorrhoidalis.*

Fig. 4.—The bean thrips : First-stage larva. Greatly enlarged. (Original.)

THE SECOND-STAGE LARVA.

(Fig. 5.)

Length, 1.05 mm.; width of mesothorax, 0.27 mm. Shape fusiform, about same as larva; of mesothorax and metathorax long, robust, cylindrical; sides of mesothorax and metathorax and first five abdominal segments nearly parallel; prothorax narrowed toward head; last five abdominal segments tapering to the last segment, which is cylindrical and truncated at end. Color of head and prothorax light yellow, mesothorax and metathorax and first six segments of abdomen translucent white, stained on sides with crimson blotches and with yellow on dorsum to some extent; next three segments of abdomen the color of head, last segment of abdomen white; alimentary tract plainly indicated by the brownish color given it by inclosed food. Surface of body covered with minute granulations. Head quadrate, rounded in front and notched behind the eyes, 0.12 mm. long, 0.0825 mm. wide; eyes small, reddish; ocelli absent. Antennæ 7-segmented, first four segments the color of head, the others translucent white; first segment short, cylindrical; second longer, barrel-shaped; third and fourth spindle-shaped and annulated; fifth, sixth, and seventh slender and cylindrical. Legs long, yellowish. Abdomen 0.60 mm. in length, fusiform, ovipositor not formed; segments with rows of fine setæ increasing in length toward posterior end; ninth and tenth segments with longer setæ.

THE YOUNG NYMPH OR PREPUPA.

(Fig. 6.)

Length, 1.02 mm.; width of mesothorax, 0.255 mm. Shape fusiform, similar to adult. Head, length, 0.09 mm.; width at eyes, 0.157 mm. Head translucent white, vertex slightly yellowish, ocelli absent. Head rounded in front, slightly notched behind the eyes; eyes red, made up of a few facets, surface faintly reticulated; two pairs of setæ behind the eyes and two pairs between the eyes. Antennæ translucent white, extending forward, 0.195 mm. in length; segments indistinct but apparently 7-segmented.

Prothorax about one-half again as wide as long, sides rounded, posterior edge broadest, semitranslucent white to yellow, posterior angles tinted with crimson.

FIG. 5.—The bean thrips: Second-stage larva. Greatly enlarged. (Original.)

FIG. 6.—The bean thrips: Prepupa. Greatly enlarged. (Original.)

setæ around margin. Mesothorax with rounded angles, translucent white to faint yellow, sides and posterior angles tinted with crimson, wing-cases transparent white, distinct from each other, those of forewings extending to middle of second abdominal segment and those of hind wings extending to middle of third abdominal segment. Legs strong, translucent white.

Abdomen fusiform as in adult, translucent white to faint yellowish, edges with tint of crimson, which enlarges to fair-sized blotches on sides of seventh and eighth segments; number of longitudinal rows of setæ increasing in length toward posterior end. Length of abdomen, 0.62 mm.

THE FULL-GROWN NYMPH OR PUPA.

(Fig. 7.)

Length, 0.99–1.09 mm.; width at mesothoracic angles, 0.24–0.255 mm. Shape similar to that of adult. Color orange; posterior border of prothorax, mesothoracic angles, sides, and abdominal segments 2, 3, 6, and 7 more or less crimson. Head, length, 0.11 mm.; width, 0.18 mm.; orange, apparently faintly reticulated; eyes dark red, larger than in prepupal stage, facets small. Three ocelli present in close triangle between eyes, in color yellow. Antennæ laid backward on head and reaching to beyond middle of prothorax; segments indistinct, translucent white; segments 1 and 2 projecting in front of the head and 2 with four setæ or hairs, two extending forward, about 0.0135 mm. in length. Thorax light orange or yellow. Prothorax about twice as wide as long. Wing-cases 0.54 mm. long, extending to seventh abdominal segment, translucent white. Length from head to end of wing-pads, 0.825 mm. Legs translucent white. Abdomen fusiform, similar to adult, surface plainly reticulated in older specimens, setæ well developed, the longest ones at posterior end. Length of abdomen, 0.612 mm.; width, 0.31 mm.; length of posterior setæ, 0.085 mm.

FIG. 7.—The bean thrips: Pupa. Greatly enlarged. (Original.)

The younger stages of this insect differ distinctly from those of *H. hæmorrhoidalis*[1] in the dashes of crimson so generally present on the sides.

The pupa of the male is shorter and more slender than that of the female. This pupa differs from *H. hæmorrhoidalis* in its smaller size, in its yellow color, with the sides of the abdomen more or less stained with crimson, and in having the hairs of the body longer and the second segment of the antennæ with two long setæ.

The foregoing descriptions are for the parts of California in Los Angeles County and more northern points, for Mr. Wildermuth

[1] For description of *Heliothrips hæmorrhoidalis*, see "The Greenhouse Thrips," Bul. 64, Part VI, Bur. Ent., U. S. Dept. Agr., pp. 46–48, 1909.

found that the different stages in the Imperial Valley lacked the red markings except in the cooler weather of the late fall.

ORIGIN AND DISTRIBUTION.

This insect was first described by Mr. Theodore Pergande from specimens taken in Yuba County, Cal. A few years later he identified a thrips from Lewiston, Idaho, as this same species.

Mr. Dudley Moulton reported that this species had been collected in Colusa County by Mr. E. K. Carnes, in Santa Rosa County by Mr. O. E. Bremner, and in the Santa Cruz Mountains, Santa Clara County, by himself. Mr. D. L. Crawford recorded *fasciatus* from Santa Paula, Ventura County, Cal., and from Claremont and Chino, Cal. Mr. William B. Parker, of this bureau, collected it at Davis and Hamilton City, Cal. Mr. P. R. Jones, engaged in pear thrips investigations, reports that this insect occurs very commonly around Lindsay and San Jose, Cal. Mr. S. W. Foster, while engaged in the same investigation, collected this insect from Martinez, Cal., and later found it " frequently throughout Contra Costa County."

Mr. V. L. Wildermuth, engaged in cereal and forage insect investigations, has collected this insect in California at Indio, Riverside County, and at Bard, El Centro, and Holtville, Imperial County, and in Arizona at Yuma, Yuma County, Buckeye and Tempe, Maricopa County, and Sacaton, Pinal County.

During the present investigation the writer has collected this insect quite extensively from many places in southern California. In 1910 it was found to be very abundant on wild lettuce in several yards and alleys in the city of Los Angeles itself. At various times it has been collected from Bell, Compton, Gardena, Glendale, Hollywood, Laurel Canyon, Puente, San Gabriel, Sierra Madre, Tropico, and Whittier, in Los Angeles County. In Laurel Canyon the author found it feeding on wild food plants in uncleared land about 6 miles from cultivated fields. It was also collected near the entrance of the canyon, scattered over the mountain sides on various wild plants. At Sierra Madre it was taken at an elevation of 750 feet.

It was also collected at Garden Grove, Huntington Beach, Smeltzer, and Sunset Beach, in Orange County, Cal. While on a trip in October, 1910, the author found this insect to be generally distributed throughout the town of Oxnard, and in Montalvo and the entire outlying sugar-beet district of Ventura County.

In February, 1911, the author made a trip to San Diego to investigate the conditions in reference to truck crops there, and in Mission Valley—a long, narrow, and fertile valley lying to the north of San Diego, and devoted to truck crops—this insect was found feeding to some extent on pea vines. The writer left California for Washington, D. C., in September, 1911, and while delayed at Sparks, Nev., he examined several clumps of wild lettuce growing along the rail-

road track and collected both larval and adult forms of the bean thrips upon this plant.

Mr. A. C. Morgan, of this bureau, recently reported to the writer that he had collected the species on October 10, 1910, at Clarksville, Tenn. The fact that this insect is so widely distributed in all parts of California seems to point strongly to that State as its original home. This is also strongly supported by the fact that Moulton collected it from wild vetch in the Santa Cruz Mountains and that the writer collected it in wild, uncultivated tracts in the mountains and canyons north of Los Angeles, 5 and 6 miles from cultivated crops. This point of view is further strengthened, because the author has found this insect feeding on more than 20 native wild plants.

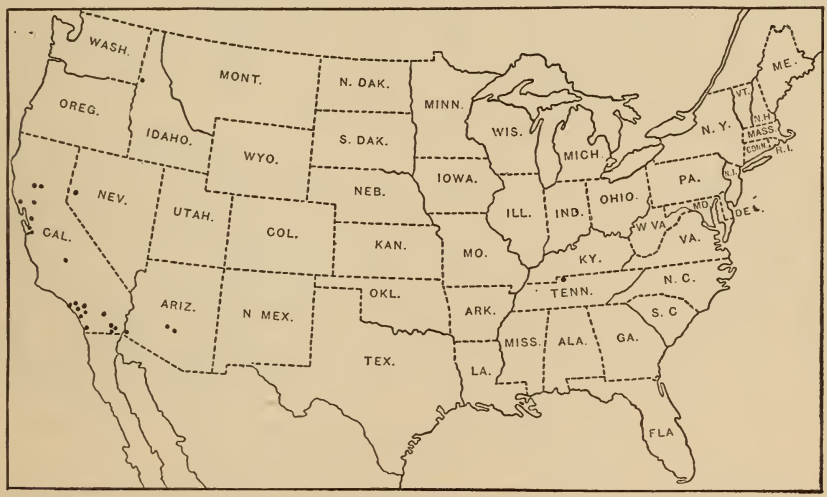

FIG. 8.—Map showing present known distribution of the bean thrips (*Heliothrips fasciatus*). (Original.)

Mr. J. D. Hood, formerly of the office of the State entomologist of Illinois, recently informed the writer that he possessed specimens of this thrips that were collected by Prof. Lawrence Bruner at Lincoln, Nebr., February 14, 1899, and that he had collected this same species at Urbana, Ill., in March, 1907. In both cases the thrips were taken on California oranges and had evidently been carried across the country while hibernating in the navel end of the fruit. This is an excellent illustration of how this insect may be distributed through the agency of man.

Although this insect is quite minute and has been little studied, at the present time it is known to occur through the entire State of California, in several places in Arizona, in Nevada, and in Idaho near the Washington State line. It has also been found in one locality in Tennessee. Figure 8 has been prepared to show the present definite localities where this insect has been observed.

Without doubt this insect occurs over the entire Pacific coast of the United States and down into Mexico for some distance and possibly even into Central America. As it becomes better known it will probably be found to occur in several of the other Western States and some of the Eastern States as well.

HISTORY.

In 1895 Mr. Theodore Pergande (1)[1] described this species from one specimen received from Yuba County, Cal., where it was taken on an orange leaf infested with (*Aspidiotus*) *Chrysomphalus aurantii* Mask. At that time he expressed the opinion that the occurrence on this plant was accidental. In view of our present knowledge, however, of the feeding habits of this insect, this specimen was probably feeding on the foliage of the orange itself.

In 1902 Hinds (3) redescribed the female from one specimen in the collection of the Bureau of Entomology. At that time he wrote that nothing was known of the life history.

Miss Daniels (4), writing in 1904, noted the occurrence of this thrips in California. At the same time she erected a new genus and species, *Caliothrips woodworthi* (4), for the male of *Heliothrips fasciatus*. This error was first pointed out by Dudley Moulton (6) in 1907, and the present writer agrees with him, as the male of *fasciatus* fits the description exactly except in the number of antennal segments. Undoubtedly Miss Daniels made a mistake in the number of segments in the antenna, since *fasciatus* is 8-segmented only.

Crawford (7), in 1909, under "Notes on California Thysanoptera," records taking numerous specimens in southern California. These were captured on pine, *Lotus glaber*, and apple.

Under the name *Euthrips fasciatus*, Bremner (8), in 1910, reported this insect as injuring beans and peas and as occurring on alfalfa and on peach and pear trees. He recommended spraying with nicotine solutions, and wrote that of these sulphate of nicotine in the proportion of 1 ounce to 5 gallons of water had given perfect success.

In 1911 Coit and Packard (9) wrote that the bean thrips caused considerable defoliation to cotton and alfalfa in Imperial Valley, Cal. Moulton (10) also gave a list of its food plants.

The present writer, in 1911 (12) and also in 1912 (13), published two papers dealing with the life history and habits of *Thripoctenus russelli* Crawf., a parasite reared in large numbers from this thrips.

RECENT RECORDS.

This species, as identified by Mr. Pergande, was sent to the Bureau of Entomology January 25, 1898, by Mr. M. J. Wessels, of Lewiston,

[1] Numbers in parentheses refer to the Bibliography, pp. 44–45.

Idaho, who collected it in a diseased spot of a crab apple. On August 27, 1908, Mr. I. J. Condit sent in specimens of this thrips from Davis, Cal., where they were injuring sugar beets. He wrote:

> I examined the beets and found them literally covered with thrips, both the surface and underside of the leaves being badly infested. There were very few leaves which were not attacked, most of them having the appearance of the specimens sent. A field of tomatoes near by was also becoming infested. The lower leaves especially were yellow and some falling off.

Mr. S. W. Foster informed the writer that on August 26, 1909, Mr. Frank T. Swett, of Martinez, Cal., sent to the laboratory of the Bureau of Entomology at Walnut Creek, Cal., a quantity of pear leaves badly injured by this species. On August 31 Mr. Foster visited the orchard and found the injury quite noticeable. He wrote that "the foliage gave the appearance from a distance of having been scalded." Mr. V. L. Wildermuth, of this bureau, sent specimens taken on alfalfa at Indio, Cal., on July 2, 1910. Mr. A. McLachlan, of Davis, Cal., sent in specimens of this thrips on October 13, 1910, with the report that they were injuring the buds and tips of cotton.

Mr. W. B. Parker, of this bureau, under date of August 25, 1911, sent this insect from Davis, Cal., with the statement that it was causing serious damage to the foilage of the sugar beet. He also collected it on sugar beets at Hamilton City, Cal., on September 18, 1911, where it was causing some injury. He wrote, however, that owing to the lateness of the season when the beets were attacked probably only slight damage resulted.

HABITS OF THE ADULT.

For a short time after emerging from the pupa this insect remains quiet and appears to be waiting for its limbs to harden. During this time the colors, which were light at emergence, gradually darken. After hardening the thrips moves off and begins feeding.

METHOD OF MATING.

The males and females of this species seem to emerge from the pupa at about the same time. During this investigation it was observed that, under laboratory conditions at least, the sexes mated generally in from two to three days after emergence and in some cases in even less time. This operation has been observed both in the field and in the laboratory and was identical under both conditions. This is probably best described by the original field notes made at the time of observation.

The male,[1] when inclined to copulate, picks out a female, and if she is moving over the leaf runs after her and jumps or alights on her back. In some cases he then spreads the wings and moves them up and down, at the same time moving the tip of the abdomen in the same manner. In other cases the male, after leaping onto the back of the female, remains motionless for some time in that position. It then exserts the copulatory organs from the tip of the abdomen and shifts around toward the side of the female, at the same time bending the abdomen under to the ventral side of that of the female. The copulating organs are then moved back and forth until they encounter those of the female. In some cases observed, when the male did not succeed in connection, it would withdraw to its former position on the female and after remaining quiet for a short time would move over and attempt the act on the opposite side. As soon as connection is made the male remains motionless for a short time, during which period the female, in many cases, crawls slowly around on the leaf. After a few minutes the male relinquishes his hold with the copulating organs and moves squarely back onto the dorsum of the female. Soon after the male crawls off and away from the female. This entire operation was observed in three cases to occupy 3, 5, and 10 minutes. Several cases were observed where two males attempted copulation with the same female, but, after a vain attempt, one generally left her.

METHOD AND TIME OF OVIPOSITION.

Exactly how much time elapses between copulation and oviposition was not observed, but probably not more than a day, so that the female will begin oviposition within three days from the time she emerges from the pupa. In one case adults emerged on July 19, 1911, and eggs were laid four days later.

Oviposition usually takes place during the night, but has been observed at 2, 3, and 4.30 in the afternoon. A female engaged in oviposition was observed to crawl over the leaf of the food plant for a short distance and then to stop and scrape a hole in the leaf with her mouth cone. This was accomplished by a slight forward and backward motion like that of a chisel. In a short time the female ceased this action and moving forward until she could place the tip of the abdomen where the tissue had been ruptured, arched the abdomen in the middle, and brought the tip to the opening in

[1] Pietro Buffa (Atti Soc. Toscano Soc. Nat. Mem., vol. 23, p. 48, 1907) figures *Æolothrips fasciatus*, female and male in copulation, in a position identical with that observed by the writer in *Heliothrips fasciatus* on many different occasions.

A. F. Shull (A Biological Survey of the Sand Dune Region of Saginaw Bay, Mich., pp. 190–192), describing copulation in the suborder Terebrantia, expresses doubt as to the position of the male on the back of the female during copulation. As his observations on *Euthrips tritici* were made under unfavorable conditions his conclusions were probably erroneous.

the leaf surface. She then proceeded to work the ovipositor back and forth in the rupture until she had made an incision of sufficient depth. After this she became motionless for a varying length of time, while the egg was being deposited, whereupon the ovipositor was removed, and the female moved away.

A number of cases have been observed where the female, after inserting the ovipositor, could not withdraw it, and, thus held, she soon died.

NUMBER OF EGGS AND PERIOD OF OVIPOSITION.

Owing to the artificial means used in studying the habits of this insect it was impossible to determine exactly how many eggs a female is capable of laying. However, the writer confined 6 females in a vial for observation. They laid an average of 35.5 eggs each, while the highest average for any day was 5.5 eggs each. Another female, during the period from August 16 to August 23, 1911, laid 16 eggs, the greatest number laid in any one day being 5. At Compton, Cal., during 1911, females kept in confinement were observed to oviposit for 30 days in succession, while others were observed to oviposit 51 and 83 days after they emerged from the pupæ. If this insect normally continues oviposition regularly over a period of 83 days the total number of eggs laid must be very large.

Mr. V. L. Wildermuth, while in the Imperial Valley, made some interesting notes on the number of eggs this species may deposit. On August 2, 1910, he confined 2 females on leaves of alfalfa in a vial, and on August 5 these leaves contained 50 eggs, or an average of 25 eggs each in 3 days. His other observations are given in Table I.

TABLE I.—*Number of eggs deposited by the bean thrips (Heliothrips fasciatus), Imperial Valley, Cal., 1910.*

Experiment No.	Date female was put in vial.	Date and number of eggs.							Total period of oviposition.	Total number of eggs.
		1910.	Eggs.	1910.	Eggs.	1910.	Eggs.	Dead.		
	1910.								*Days.*	
1	Aug. 29	Sept. 1	36	Sept. 2	6	Sept. 6	37	♀	7	79
2	Aug. 31	Sept. 4	42	.....	.....	.....	.....	♀♀	3	42
3	.....do.....	Sept. 7	53	.....	.....	.....	.....	♀♀	6	53
4	.....do.....	Sept. 1	20	.....	.....	.....	.....	♀	1	20
	1911.									
5	Sept. 28 [1]	Sept. 30	12	Oct. 3	25	Oct. 11	24	}	46	134
				Oct. 21	47	.....	.....			
				Nov. 1	27	Nov. 11	11			

[1] Record made at Tempe, Ariz.

In these experiments the longest period of oviposition was 46 days, and the largest number of eggs laid by a single female, 134.

It will be observed from these figures that the females observed by Mr. Wildermuth deposited more eggs and at a more rapid daily rate

than those observed by the writer. This may have been due to the higher temperature of the Imperial Valley and vicinity, where his observations were made. Mr. Wildermuth noted adults in copulation the day that they emerged, and oviposition on the following date. He also observed this species to oviposit during the entire day, whereas the writer never observed it to oviposit except in the afternoon or night.

PROPORTION OF THE SEXES.

The bean thrips was under the observation of the writer for a period of more than two years, during which time it had been observed in the field at all times of the year. In all observations made during the investigation of this insect the males and females were collected together and copulation was observed from early in February until reproduction ceased late in the fall. Apparently the females outnumber the males, but this may be due to the fact that the females are not quite so active as the males, and are not disturbed on the plants when examined. On June 9, 1911, out of 17 specimens reared in the laboratory 9 were females and 8 males. July 17, 1911, the writer examined another series of live adults that were reared in the laboratory. Out of 106, 80 were females and 26 males. A third series of reared adults was examined October 16, 1911, and out of 44 adults 32 were females and 12 males. Apparently the percentage of females is too high and does not indicate the exact relation between the sexes.

KINDS OF REPRODUCTION.

In all observations made on this topic reproduction has been bisexual, and in view of the fact that males were observed at all times and copulation also occurred at all times in the year when this insect was active, this would seem to be the usual method. However, although the few experiments made to determine whether parthenogenesis occurred gave negative results, in view of the preponderance of females during certain parts of the season it is quite probable that asexual reproduction may occur. It would seem that this method would occur under certain conditions, especially in view of the fact that the greenhouse thrips (*Heliothrips hæmorrhoidalis*)[1] reproduces, so far as we know, asexually only, the male having never been discovered.

FEEDING HABITS.

Both the adult and larva of this thrips injure the host by feeding on the foliage. As in the case of the greenhouse thrips, the lower

[1] "The Greenhouse Thrips," Bul. 64, Bur. Ent., U. S. Dept. Agr.

and earlier leaves are first attacked in the spring by the adults. These feed on the underside of the leaves, scraping out the leaf content in small spots that become white and conspicuous. Often the adults move along and leave a chain of white spots to mark their progress. The adults also feed to some extent on the surface. As they feed the females deposit their eggs in the leaf tissues, and as soon as incubation is completed the larvæ hatch and join the adults on the leaves. Under these conditions the leaves become more or less dried and lifeless, and the adults move to the higher and more tender leaves of the plant. In this way the entire plant may become infested. On February 5, 1911, the writer found the adults of this insect extremely abundant in the pea field of some Chinese truckers at Hollywood, Cal. Here nearly every plant had 7 or 8 adults feeding on the underside of the foliage, and in many cases 5 and 6 were present on each leaf. On August 18 of the same year in the same locality plants of spiny wild lettuce (*Lactuca scariola*) were observed that had 50 adults feeding on a single leaf.

The adults seem to feed on a large variety of plants and have been found feeding on all of the plants given under "List of food plants." It may be well to state at this point that the presence of adults on a plant has not been considered sufficient evidence to class that plant as a food plant, but whenever larvæ of this insect were taken on a plant, this was considered sufficient to rank the plant as a host.

In the spring when the adults leave hibernation they collect on the wild food plants present and feed on them until their injury, due to an increase in numbers and feeding, weakens the plants and shortens the food supply; then they fly to fresh plants of the same hosts or to cultivated crops and fruit trees nearby. Of all the food plants observed, the spiny wild lettuce (*Lactuca scariola*) seems to be the most favored. This plant has been found to be infested more heavily than any of the other food plants concerned, not excepting those of economic importance.

FLIGHT.

The present writer in his investigations of the greenhouse thrips[1] never observed that insect to take flight naturally, or even when disturbed. The adults of *Heliothrips fasciatus*, on the contrary, take flight very readily, and if jarred or disturbed will usually fly or jump. This species in taking flight raises the tip of the abdomen quickly, and separates the wings. It then rises straight up into the air and flies rapidly away in short undulating curves. Indeed, to the untrained eye it appears, in flight, exactly like a small speck of soot being blown around by a slight breeze. This power of flight aids greatly in the dispersion of this insect during the spring and summer.

[1] Loc. cit.

LEAPING.

This species possesses the power to leap actively and, considering its size, to a considerable distance. It is no uncommon occurrence for the specimens which are being examined upon a plant to leap off and be lost. Like the greenhouse thrips, it will crawl over the leaves rapidly when disturbed. At other times it will remain motionless for a considerable period, lying closely to the surface of the leaf along one of the veins.

NORMAL LENGTH OF LIFE.

The length of life of this insect as an adult has been determined under the artificial conditions of confinement in vials containing fresh leaves of the food plant. As often as these lost their freshness other leaves were put in and the adults were changed with a camel's-hair brush.

Even under these conditions the length of life observed for some individuals was surprisingly long, when we consider the minute size of the insect. During these experiments it was observed that these insects were very sensitive to humidity or a lack of it and all were soon killed whenever the vials used in confining them became too dry. Table II shows the results of these experiments in which some thrips lived for 84 days.

TABLE II.—*Length of life of adult bean thrips at Compton, Cal., 1911.*

Date adults emerged from pupa.	Number emerged.	Specimens died.		Last adult died.	Maximum length of life.
		Date.	Number.		
					Days.
April 16	3	May 8	1	May 22	37
		May 11	1		
April 23	11	May 8	1[2] 2[4]	July 14[3]	84
		May 18	1		
		May 26	1		
		June 5	1		
June 5	9	June 17	5	Aug. 14	71
		June 21	3		
July 19	14	July 22	2	Aug. 21	34
		July 25	2		
		July 26	2		
		Aug. 8	2		
		Aug. 12	2		
		Aug. 17	1		

[1] Dead. [2] Lost. [3] Male and female.

LENGTH OF LIFE IN WINTER.

A number of adults were collected from host plants on November 18, 1910, and were placed in vials and furnished with fresh leaves at intervals, and some lived in confinement in this manner until February 1, 1911, by which time all had died. On January 16, 1911, a num-

ber of adults were taken from the open on leaves of nasturtium and were placed in vials. These died in April, giving a length of life after being collected of 92 days. As adults have never been observed to emerge from pupæ later than December 27, these adults must have been at least 21 days old when collected, so that they lived about 113 days. Probably hibernating individuals live as long as 5 months.

HABITS OF THE LARVA.

In observing the habits of the larva of this thrips, the writer was constantly impressed with the great similarity that existed between this species and the greenhouse thrips. This is so great that the description of habits of the one would almost equally fit the other.

HATCHING.

Apparently the hatching process may occur at any time during the day. Many have been observed hatching early in the morning and one larva was observed emerging from the egg cavity at 4.25 p. m. Very slowly this larva pushed its way out of the egg cavity,[1] during which time the appendages were all held closely appressed to the body and were invisible. As soon as the body was nearly out the insect began a slow forward and backward movement and at 4.40 p. m. all but the tip of the abdomen was free, while the larva projected straight out from the leaf surface. While held in this position it began slowly to unfold the limbs and antennæ and move them around. The motion was very feeble at first, but gradually the larva seemed to gain strength and at 4.48 p. m. it bent over and, grasping the leaf surface, began to pull with its limbs in order to free itself. This was accomplished at 4.53 p. m., making the total period required in emerging from the egg 28 minutes.

The larvæ of this insect after hatching move away a short distance, then appear to rest for a few minutes until they become stronger. Within a short time, however, they move on and soon commence feeding. When first hatched the larvæ are very minute and almost colorless, but as they begin to feed and drain the green coloring matter from the leaf the alimentary tract becomes plainly visible from the contained food. In a few days the color of the body becomes more or less yellowish and blotched with crimson. In common with other species of Heliothrips, the larvæ of the present species keep the tip of the abdomen elevated and carry around on it a small globule of reddish liquid excrement. Gradually this globule increases in size until it is too large to be carried any longer and it falls to the leaf surface. Here in time it dries and forms a black spot or scale. The occurrence of these spots on the leaf of a plant

[1] This larva emerges from the egg by the same method that is used by the conchuela (*Pentatoma ligata* Say) as described by Morrill (Bul. 86, Bur. Ent., U. S. Dept. Agr., pp. 38–39).

marked by feeding of some thrips furnishes good evidence that the bean thrips has been feeding there at some time. The larvæ feed in much the same manner as the adult, the mouthparts being practically the same. They gradually scrape out the contents of the leaf, leaving silvery spots, which as they become abundant often unite and gradually destroy the vitality of the leaf. Most of the eggs seem to be laid on the underside of the leaves, although the writer has observed eggs to hatch from the upper side also. As a consequence the larvæ begin feeding largely on the underside of the leaves. After hatching they do not move far before commencing to feed, during which time, under ordinary conditions, they move very little. When plants are first infested the larvæ seem to feed close to the leaf veins, but as they become more abundant they scatter in groups over the entire leaf surface. Like those of the greenhouse thrips the larvæ of this species seem to cluster in colonies and unless disturbed, or in need of fresh food, remain thus. The colonies are in many cases found in between two veins of the leaves. When disturbed the larvæ will violently twitch the end of the abdomen with its drop of liquid and move away rapidly. Apparently this is used as a means of defense, for the writer, in work with a parasite of this thrips, observed at times that these larvæ when touched from in front by the parasite flung the abdomen around and moved rapidly away. When this occurred the parasite generally retreated, but returned to the attack and later usually succeeded in ovipositing in its host.

The larvæ and adults of this thrips feed together in colonies, and as the leaves become crowded or dry from excessive feeding the larvæ move in search of fresh food. Gradually the whole underside of the leaf attacked becomes infested by the larvæ and then the surface as well. In fact, the writer has seen leaves so heavily infested by the larvæ of this thrips as to give them a decidedly larvæ move in search of fresh food food. Gradually the whole under reddish color, due to the bodies of the insects. So far this larva has not been observed feeding in the blossoms of any plant, but in some cases it has been observed feeding on green tomatoes, and when bean vines are badly infested the pods are also attacked. Indeed, when excessively abundant, these insects will not only cover both sides of the leaves, but the stem of the plant as well. The larvæ as a rule feed unprotected on the leaf, but at times may be found feeding under the protection of red-spider webs.

Apparently these minute creatures are not affected by dust, as the writer has found them feeding in large numbers on leaves of spiny lettuce in an alley in the city of Los Angeles when the leaves were so thickly covered with dust as completely to hide the surface. It would seem that with the enormous clouds of dust that arise in this section during the entire summer, completely coating the larvæ, they would speedily succumb.

As an illustration of how abundant this insect may become, the following observations are given: On August 31, 1909, Mr. Foster, of this bureau, found it severely infesting pear foliage at Martinez, Cal., and noted as many as 200 larvæ on one side of a leaf. On July 28, 1910, the writer found some plants of spiny lettuce badly infested by the larvæ of this thrips, and 10 leaves gave a total infestation of 733. (See Table III.) This gave an average of 73.3 to each leaf.

TABLE III.—*Infestation of Lactuca scariola by larvæ of the bean thrips.*

No. of leaf.	Number of larvæ on under side.	Number of larvæ on upper side.	Total number of larvæ on leaf.	No. of leaf.	Number of larvæ on under side.	Number of larvæ on upper side.	Total number of larvæ on leaf.
1	70	7	77	7	44	47	91
2	34	39	73	8	61	30	91
3	43	2	45	9	70	1	71
4	30	2	32	10	23	32	55
5	59	47	106				
6	46	46	92		480	253	733

On July 18, 1911, at Hollywood, Cal., leaves of spiny lettuce were found that had several hundred larvæ to a leaf. September 22, 1910, Mr. Wildermuth observed a field of cotton at El Centro, Cal., showing considerable injury by this insect, and counted as many as 200 larvæ to a single leaf.

MOLTING.

The larva molts once, giving two larval instars, then molts to the prepupal stage. On July 28, 1910, a number of larvæ that had just hatched were separated and on August 2 these all molted. On August 7 they again molted and changed to prepupæ. This gave the first instar a length of five days and the second a length of five days. The process of molting in the larva is continued unprotected in the midst of the feeding colony. After molting the skin is left adhering to the leaf beside the feeding larva.

It was observed with the larvæ of this species and of those of the greenhouse thrips that when they were exposed to a low temperature the entire development was checked and growth remained stationary during the exposure. In long-continued exposures the insects were killed, but if within three weeks they were again removed to higher temperatures the larvæ resumed their growth and pupated in a few days.

Under the artificial conditions of rearing in vials the mature larvæ seek concealment before pupation in curled-up leaves, in all kinds of protected places, and if in vials closed with cotton plugs they work their way in between the plug and side of the vial. In the field, however, the larvæ when full grown desert the plants and hide in rubbish and cracks in the ground or beneath clods of earth.

The molting from larva to prepupa under laboratory conditions has been observed many times. On April 10, 1911, a mature larva was observed to begin the process at 4.05 in the afternoon. After remaining motionless for some time it arched its body, and shortly after the skin split down the head behind the antennæ. The head gradually forced its way out of the opening, then the body followed, the old skin being slipped off behind. This molting was completed at 4.21 p. m.

HABITS OF THE PREPUPA AND PUPA.

The prepupæ of this insect are found in company with the pupæ and full-grown larvæ in small social colonies. These hold the antennæ out in front of the body and move about to some extent. The pupæ, however, carry the antennæ folded back on the head and thorax and remain motionless unless disturbed or exposed to the light, in which cases they will slowly crawl away. When compelled to pupate in closed vials the prepupæ and pupæ occur in large numbers closely packed together along the edge of the vial and the cotton plug or buried in the cotton itself. In nature it has quite different habits. While the greenhouse thrips under natural conditions pupates on the leaf of the food plant in among the feeding larvæ, with the bean thrips this seldom takes place, and during the two years this species has been under observation by the writer only three pupæ have been found on the plants infested by hundreds of thousands of larvæ. In one case a pupa was found under the web of the red spider near the midrib of a leaf of spiny lettuce; in another, one was found under a web of red spider on a leaf of the wild tobacco flower; and the third was found in a curled-up lettuce leaf.

December 17, 1910, a quantity of the dead leaves of wild heliotrope were collected on the ground under infested plants. Prolonged sifting revealed the presence of a single pupa. In 1911, the prepupæ and pupæ were found by Mr. John E. Graf and the writer to be very abundant in infested bean fields under clods or lumps of dry earth and in cracks or holes in the lumps. Upon exposure to the light these at once began to move away in search of darkness.

Mr. Wildermuth also found the pupæ of this insect underground. He wrote in his notes on September 23:

> While searching by aid of a binocular for pupæ, I found one pupa, one prepupa, and two (mature) larvæ just at the crown of the plant and beneath the soil; one pupa about one-fourth inch below the surface of the soil in an oval cavity about three times as long as the pupa itself; one prepupa between a dead leaf and the soil. Never have I found a pupa above the surface of the ground, on the leaves of the plant, or between the sheath leaves and the stem, as frequently occurs in confinement.

The molting of the prepupa to the pupal stage is very similar to that described for the change of the larva to the prepupa. It takes

place in whatever location the prepupa may be, and the transparent and delicate empty skin is found behind the pupa. It was observed during the fall that pupæ exposed to a low temperature did not complete their development to the adult stage. These, when later placed in the greenhouse, changed to adults unless exposed to the unfavorable conditions too long, when all were killed.

During the pupal stage several external changes take place. At first the ocelli are not evident, but as the pupa develops these become prominent in a triangle between the folded antennæ. Then the reticulations of the body begin to appear, and within two days of the emergence of the adult the pupa begins to darken and the legs, antennæ, and wings begin to show blackish bands. The adult emerges in a manner similar to the molting of the larva. Emergence has been noted at all hours of the day, and there seems to be no particular time for its occurrence.

FOOD PLANTS.

This insect seems to be nearly as omnivorous as the onion thrips, as the following list of food plants upon which it has been reared or observed during the past two years by the writer would indicate. These have been divided into economic and wild food plants, and under each will be given notes on injury and appearance of injured plants.

BEANS.

The injurious occurrence of this insect on the foliage of beans gives to it its common name. It has been observed by the writer to feed on bean foliage in the adult and larval stages from early in February, in sheltered places, until the plants are killed by frost in the fall. In the spring the wild plants are first up, and the attack is largely concentrated on them, so that when the beans come up they are not immediately attacked. However, in a few weeks the insect spreads to the beans, thereafter increasing in numbers until in the late summer and fall much injury is done. When snap beans are infested the adults first attack the leaves, and while feeding lay countless eggs in the tissue. The larvæ on hatching begin to feed, and gradually the green coloring matter is entirely removed from the underside of the leaf. This becomes white and covered with the black spots of excrement. The infestation then spreads to the surface and to other parts of the plant. As the feeding goes on the leaves lose all color, become white, or dry up and turn brown and drop off. As the infestation increases, the stems and pods themselves are also attacked and ruined. A badly infested field appears as if scorched by fire. The lima bean and pink bean suffer in the same way. The blackeye cowpeas this past season were almost immune from the attack of this insect, even in fields in which the pink beans and spiny lettuce were very badly infested.

OTHER VEGETABLES.

During the spring and early summer this insect is not noticeable on either the sugar or table beets. Late in the summer, however, as the wild plants die down, these plants often become badly infested, but as the beets have nearly completed their growth little real injury results. The outside leaves seem to be first infested, showing series of minute white spots more or less in chains, where the chlorophyll has been removed, but in badly infested leaves the underside becomes white and dried and covered with small black spots, causing the leaves to wilt. Mr. Parker wrote from Hamilton City, Cal., under date of September 18, 1911, that the injury was apparent in almost every field.

Cabbages and other crucifers are commonly infested by this thrips and at times may be seriously injured. On March 27, 1911, cabbages in the laboratory yard were slightly infested. Where they had fed long the underside of the leaf was full of the silvery-white feeding marks of this insect and the tiny black specks of excrement. Cauliflower suffers to the same extent as the less valuable cabbage.

This insect has also been found feeding quite extensively on lettuce, potato, and tomato. At Hollywood, Cal., in February, 1911, it was very abundant on the foliage of pea vines, but the infestation did not appear to increase, probably because the vines were quite old.

PEAR.

Mr. S. W. Foster found pear foliage badly injured on August 31, 1909, at Martinez, Cal. He wrote:

> The foliage gave the appearance from a distance of having been scalded. Close examination showed that the leaves were often injured in large areas on either or both surfaces. The larvæ, feeding only on these outer surfaces, soon cause the blackened areas.
>
> As the tree has made most of its growth for the season and the fruit crop has been harvested, it is hardly probable that this species will prove of serious consequence to the growers unless it should get so numerous as to appear in numbers early in the season.

ALFALFA.

The following field observations on the work of the bean thrips on alfalfa and cotton were made by Mr. Wildermuth in the Imperial Valley, Cal.:

> August 2, 1910. This thrips does nearly all if not all of its feeding on the upper surface of the leaf. The excrement is arranged in definite rows, often semicircular in form, around these eaten spots and makes a very characteristic mark [see fig. 9]. The eaten spots later turn yellow and then the alfalfa presents a sickly appearance. August 4 I visited several alfalfa fields and all were very much injured by this thrips. Scarcely a leaf could be found that

was green and fresh as it should be. The fields examined have a whitish-yellow cast to the usual green appearance. August 30 several fields were visited and every leaf in the fields examined was attacked by the thrips. The alfalfa has a whitish and bleached appearance, due to the effects of the thrips' feeding. I never saw anything to equal this in appearance or in thoroughness

FIG. 9.—Alfalfa showing injury by the bean thrips. (Original.)

of attack. September 30 the fields were still being badly damaged. After a field is newly irrigated just after cutting for a week or 10 days the damage is not noticeable, but after three weeks nearly all leaves show the effects and the alfalfa presents a very sickly appearance. A lack of sufficient water causes the damage to be more noticeable, as under such a condition the growth of the alfalfa is not so rapid and the thrips' damage is more conspicuous.

On September 18, 1911, he wrote:

This thrips is very abundant in alfalfa fields at this time of year, the larvæ being present on the older alfalfa and the adults present on the younger shoots and leaves. Many leaves, after being badly scarred by the thrips, wilt and fall off, so that the damage is soon very great. It seems rather strange that this thrips should become so very abundant in the fall of the year and *Euthrips tritici*, the other important alfalfa thrips, should decrease in numbers and that in the spring of the year just the opposite should be the case.

COTTON.

September 22, 1910, Mr. Wildermuth wrote:

This thrips was found damaging cotton about 11 miles southeast of El Centro, Cal. The cotton was only damaged in one corner of the field, and it happens that fresh alfalfa is being stacked close to this corner.

September 28 a field of cotton east of Imperial had a strip through the center of the field damaged by this thrips. September 30 numerous fields on the east side of the valley were being damaged by this pest. The leaves were dead and rusty looking and the plants in bad condition. The damage was not as great as if the work had begun earlier in the season, but was at that time very great.

October 11 several cotton fields at Holtville, on the east side of the valley, were examined. A great many fields showed considerable injury. The leaves were eaten and turned a sickly yellowish or brown, many often being curled. A field on the Young ranch was as badly damaged as any seen, and this field lay alongside an alfalfa field. Three other fields on the same ranch showed very little damage. The former field was of a late planting. This thrips has caused much more damage to cotton than was anticipated, and if it should begin its work early in the season it might prove extremely destructive. Because of this, as well as other still better reasons, cotton should be planted as early as possible in the spring.

In November, 1911, Mr. Wildermuth wrote:

Mr. Packard and cotton growers throughout the valley report but little injury to cotton by this thrips this year. I found only two specimens of larvæ myself, and a few adults. It would seem as if the damage to cotton comes when cotton follows alfalfa. This year, there being but little alfalfa land put to cotton and more cotton following cotton, the damage was not so noticeable.

WILD PLANTS.

Of all food plants of this insect the wild spiny lettuce (*Lactuca scariola*) seems to be preferred, at least in the vicinity of Los Angeles. From early spring, when this plant comes up, until it dies down in the fall, it is usually badly infested by thrips. Many cases have been observed where other food plants, such as beans, etc., in the same field were only slightly infested, while the spiny lettuce near by was so badly attacked that many plants were dead. Furthermore, this weed is one of the commonest in the country, occurring abundantly in uncultivated or even in badly cultivated fields. In addition it grows up in dense clumps in all fence rows and roadsides, and the rights of way of the different railroads are densely packed by this plant.

When this weed first comes up in the early spring there is scarcely any vegetation, so that it offers an agreeable host to the bean thrips, especially as the foliage is very tender and juicy at that time. The thrips attack the first young leaves, and the larvæ, upon hatching from eggs deposited at that time, join the feeding adults. As soon as these become abundant, the leaves lose all or nearly all of the green leaf-content and turn white, after which they dry up and hang dead from the stalk. The infestation continues to spread to the younger leaves until the entire plant is killed.

The sow thistle (*Sonchus oleraceus*) has the same general distribution and is also a favorite food plant.

Wild heliotrope (*Heliotropium curassavicum*) is another favorite food plant late in the year. This plant does not start in the spring until quite late, and when it does appear above the ground generally escapes destruction by cultivation. Thus it occurs commonly in the beet and bean fields and in orchards, and in the fall is one of the chief food plants.

The bean thrips has also been found feeding and reproducing in numbers on *Euryptera lucida* and on one of the cucurbitaceæ, probably an Echinocystis, in a canyon north of Los Angeles. In the same locality it was later taken feeding and reproducing on *Gnaphalium californicum*, *Mirabilis californica*, *Eunanus brevipes*, *Chenopodium murale*, *Helianthus annuus*, *Atriplex* sp., wild turnip, *Erigeron canadensis*, and wild pea (*Lotus americanus*). It was also taken in the valleys feeding and reproducing on the Chinese cigarette flower (*Nicotiana glauca*), *Bidens pilosa*, *Verbascum virgatum*, *Polygonum aviculare*, and *Crepsis* (?) sp. The adults were also taken in the fall feeding on the foliage of a porch vine, *Tacsonia mellissimus*, and on the cultivated nasturtium (*Tropæolum major*). Mr. A. C. Morgan found it on the underside of the leaves of the tulip poplar at Clarksville, Tenn.

This thrips has also been recorded as feeding on *Lotus glaber*, apple, peach, orange, wild vetch, burr clover, and radish.

After perusal of the above list of food plants it is easy to see how this insect can obtain a foothold in a cultivated crop in the late summer, especially as many of the wild plants die from maturity or lack of moisture, thus forcing the insect to migrate.

SEASONAL HISTORY AT COMPTON, CAL.

The life cycle of the bean thrips was observed at Compton for varying parts of the year, and because of the cooler and more even temperature prevailing there is quite extended and more nearly equal for the entire period of reproductive activity.

THE EGG.

The length of time required for the egg to hatch in the months of March, April, and May was not exactly determined. However, fresh

leaves of wild lettuce were collected on April 7 and they had a number of eggs in them very recently laid. The last of these hatched on April 24, making the length of incubation about 17 days, or possibly as many as 21 days. The average mean temperature for these 21 days was 59.1° F.

In July several adults of this thrips were confined over night on leaves of growing plants that were uninfested, and were removed on the following morning. In this way a number of eggs were obtained that hatched under absolutely normal conditions, as the plants were kept in an open-air insectary.

Table IV has been prepared to show the records of incubation for these eggs.

TABLE IV.—*Length of egg stage of the bean thrips in July at Compton, Cal., 1911.*

Date of oviposition.	Dates eggs hatched and number each day.								First egg hatched.	Last egg hatched.	Shortest incubation.	Longest incubation.	Total eggs hatched.
	July 23.	July 24.	July 25.	July 26.	July 27.	July 28.	July 29.	July 30.					
											Days.	*Days.*	
July 10	5	54	16	3	2	6	.....	.....	July 23	July 28	13	18	86
July 11	.....	26	18	9	7	.....	.....	.....	July 24	July 27	13	17	60
July 14	.....	.....	.....	.....	.....	8	15	.....	July 28	July 29	13	14	23
													169

In this experiment 169 eggs hatched and the minimum length of incubation was 13 days and the maximum 18 days, but nearly 50 per cent hatched in just 14 days. During this total period the average mean temperature was 69.6° F.

Again, on August 20 adults were confined over night on a living plant of wild lettuce, and 4 larvæ hatched on September 4, and 7 on September 5, making the periods of incubation 15 and 16 days. During this time the average mean temperature was 66.3° F.

During the months of October and November the incubation is probably lengthened a few days and will take about 21 days, as the average mean temperature for these months was, respectively, 58.67° and 55.3° F.

THE LARVA.

The length of time occupied by this insect in the larval stage during the months of March, April, and May was observed during the year 1911 by confining larvæ that had just emerged in vials constantly supplied with fresh food. Table V gives the results of these observations. While in the first part of this period the length required was from 17 to 19 days, later it was shortened to 9 and 11 days. The average mean temperature for the first period, March 19 to April 7, was 61.5° F. and for May 14 to May 27 it was 61.1° F.

TABLE V.—*Length of larval stage of the bean thrips, Compton, Cal., March and May, 1911.*

Date larvæ hatched.	Number of larvæ hatched.	Larvæ pupating.		Length stage.		Average mean temperature.
		Date.	Number.	Minimum.	Maximum.	
				Days.	*Days.*	°*F.*
Mar. 19	8	Apr. 5	1	17	19	61.5
		Apr. 6	2			
		Apr. 7	[1] 1			
May 14	7	May 24	1	10	11	62.1
May 16	15	May 26	4	10		
		May 27	1			
May 18	14	May 27	4	9	11	62.1

[1] Rest killed by heat.

During June and the first part of July this method of rearing larvæ to secure the length of instars was repeated, with the results shown in Table VI.

TABLE VI.—*Length of larval stage of the bean thrips in June and the first part of July, 1911, Compton, Cal.*

Exp. No.	Eggs hatched.		Larvæ pupated.		Total pupated.	Duration of stage.		Average mean temperature.
	Date.	Number.	Date.	Number.		Minimum.	Maximum.	
						Days.	*Days.*	°*F.*
1	June 15	5	June 28	1	2	13	16	63.9
			July 1	1				
2	June 29	50	July 10	3	11	11	13	66.7
			July 11	4				
			July 12	4				
	June 29	50	July 11	7	11	11	12	
			July 12	4				
	July 1	50	July 13	3	3	12	.....	.....

Here the minimum for the larval stage was 11 days and the maximum 14 days.

In July larvæ were reared from eggs laid in normal growing plants, situated in an outdoor insectary under normal conditions. These experiments are all given in Table VII.

TABLE VII.—*Length of larval stage of the bean thrips in July, 1911, at Compton, Cal.*

Exp. No.	Eggs hatched.		Date and number of larvæ pupating.	Total larvæ pupating.	Length of larval stage.		Average mean temperature.
	Date.	Number.			Minimum.	Maximum.	
					Days.	*Days.*	°*F.*
1	July 23	5	July 31, 85 larvæ feeding; Aug. 2, all but 10 left plant to pupate; Aug. 5, 10 prepupæ.	85	10	12	68.8
	July 24	54					
	July 25	16					
2	July 24	26	Aug. 2, all larvæ left plant to pupate in cracks. These larvæ were feeding from 7 to 9 days and then left the plant.	.....	.....	.....	68.8
	July 25	18					
	July 26	9					
3	July 28	8	.....	.....	.....	.....	65.4
	July 29	15	Aug. 9, number of larvæ pupated.	.....	11	.....	

In these experiments the larvæ were observed to feed for a period of 9 to 10 days and then to leave the plant to pupate, and 10 to 12 days were required between hatching from the egg and changing to prepupæ.

During the year 1910 a number of larvæ that hatched on July 28 were observed to change to prepupæ on August 7, the total length of the larval stage being 10 days, with an average mean temperature of 72.1° F.

The length of this stage later in the summer and in early fall for this locality unfortunately was not observed, but was probably somewhat shorter for August and September and considerably longer in October and November.

THE PREPUPA AND PUPA.

As the prepupa and pupa are two distinct stages, although closely related, the length of each was separately determined. These two stages during the spring of 1911 required from 3 to 6 days for the prepupa and from 9 to 14 days for the pupa, or a total of from 14 to 19 days. The results are shown in Table VIII, with the average mean temperature for each experiment.

TABLE VIII.—*Length of prepupal and pupal stages of the bean thrips at Compton, Cal., during March to May, 1911.*

Exp No.	Larvæ changed to prepupæ.		Prepupæ changed to to pupæ.		Adults emerged.		Length of stage.			Average mean temperature.
	Date.	Number.	Date.	Number.	Date.	Number.	Prepupal.	Pupal.	Total.	
							Days.	*Days.*	*Days.*	°*F.*
1	Mar. 31	5	Apr. 3	5	Apr. 17	5	3	14	17	59.2
2	Apr. 10	1	Apr. 15	1	Apr. 24	1	5	9	14	59.5
3	Apr. 19	1	Apr. 25	1	May 4	1	6	9	15	57.9
4	Apr. 24	2	Apr. 29	1	May 10	1	5	11	16	56.9
	Total	9		8		8				

In the month of July these stages required from 1 to 4 days for the prepupa, and from 4 to 7 days for the pupa, or a total of from 5 to 11 days. The number that required less than 7 days, however, was very small. During this month the average mean temperature was 69° F.

Table IX shows the results of these experiments and the average temperature for each.

TABLE IX.—*Length of prepupal and pupal stages of the bean thrips at Compton, Cal., during July, 1911.*

Exp. No.	Changed to prepupa.		Changed to pupa.		Adults emerged.		Length of stage.			Average mean temperature.
	Date.	Number.	Date.	Number.	Date.	Number.	Prepupal.	Pupal.	Total.	
							Days.	*Days.*	*Days.*	°*F.*
1	July 1	7	July 5	7	July 11	2	4	6–7	10–11	71.7
					July 12	5				
	July 10	3	July 13	3	July 18	3	3	5	8	
2	July 11	7	July 14	6	July 18	7	3	4	7	70.1
			July 15	1						
	July 13	3	July 14	1	July 19	.....	1–2	4–5	5–7	
			July 15	2						
3	July 15	1	July 17	1	July 24	1	2	7	9	71.6
	July 16	1	July 18	1	July 24	1	2	6	8	
4	July 19	2	July 23	2	July 29	2	3	6	9	68.5
	July 20	2	July 24	2	July 29	2	3	5	8	

During the month of August, 1910, at Los Angeles, Cal., larvæ changed to prepupæ August 2 and the adults emerged on August 9, requiring 7 days for the prepupal and pupal stages. For this period the average mean temperature at Compton, 10 miles out, was 72.4° F. Another lot changed to prepupæ on August 7 and the adults emerged on August 15, giving a total of 8 days for the prepupal and pupal stages. The average mean temperature at Compton for the period was 71.4° F.

For the latter part of August and for September the length of these stages is nearly that required in July. However, in October this time is lengthened to some extent. Larvæ that changed to prepupæ on November 3, 1910, required until November 16 before the adults emerged, or a total of 13 days. The average mean temperature for the period was 59.9° F.

Records made of the length of the prepupal and pupal stages for November and December, 1910, as given in Table X, show that at that time of year the period required was greatly prolonged, the prepupal stage requiring from 7 to 9 days and the pupal stage from 20 to 24 days, making a total period of from 27 to 33 days. During this period the mean average temperature was 53.58° F.

TABLE X.—*Length of prepupal and pupal stages of the bean thrips for November, 1910, at Compton, Cal.*

Exp. No.	Changed to prepupa.		Changed to pupa.		Adults emerged.		Length of stage.		
	Date.	Number.	Date.	Number.	Date.	Number.	Prepupal.	Pupal.	Total.
							Days.	*Days.*	*Days.*
1	Nov. 14	1	Nov. 21	1	Dec. 12	1	7	21	28
2	Nov. 16	2	Nov. 23	2	Dec. 13	1	7	20–22	27–29
					Dec. 15	1			
3	Nov. 17	7	Nov. 25	4	Dec. 15	1	8–9	22–24	30–33
			Nov. 26 or 27.	2	Dec. 17	3			
	Total	10	.....	9	.....	7	.....	.....	.....

TOTAL LIFE CYCLE.

For localities with climatic conditions similar to those of Compton, the life cycle of this thrips will occupy during the early spring about 51 to 56 days, taking 20 days for the egg incubation, 17 to 19 days for the larval development, and 14 to 17 days for the prepupal and pupal stages.

During the months of June to October the life cycle of this thrips will occupy from 28 to 43 days, taking 13 to 18 days for the egg stage, 10 to 14 days for the larval stage, and 5 to 11 days for the prepupal and pupal stages.

During the rest of the breeding activity the life cycle must be even longer than in the spring, as in November, 1910, the prepupal and pupal stages alone occupied from 28 to 33 days, so that for the development of this insect during October, November, and the first of December at least 68 to 73 days must be required.

EMERGENCE FROM HIBERNATION.

In 1912 the adults began to emerge from hibernation at Hollywood, Cal., in January, and began oviposition at once. When this locality was visited on February 7, the adults were found to be feeding on the foliage of peas and beans in some numbers. They were also seen in copulation in many cases. A careful examination disclosed 4 young larvæ feeding on bean foliage, so that the adult must have laid the eggs at least by January 10. This field was situated on the foothills of what is termed a frostless belt, and it may be that this insect in mild winters might breed there during the entire period.

On February 17 adults were found feeding on pea foliage in Mission Valley, San Diego County, but no young were seen. February 23 the species was found as an adult feeding on pea vines in the truck farms around Los Angeles, and on March 13 adults were found feeding in small numbers at Compton, Cal. From then on the adults were common feeding on different plants, but not until April 17 were the larvæ found feeding in the open at Compton, although they were being reared in the open insectary at that place from material collected at Hollywood.

It would probably be better to say that this insect begins active reproduction at a varying time, those in the most protected places starting as early as January 10, and the others over the next 60 days. However, during the early spring the multiplication and spread seem to be very slow.

ENTRANCE INTO HIBERNATION.

As the month of October appears, the adults become sluggish, do less feeding and lay fewer eggs, and apparently many enter hiberna-

tion. The larvæ become much less numerous and require an extended period to complete their growth. In 1910 the last larvæ in numbers were observed in the field on November 20, while one was observed on December 1, and three on December 13, and during the first part of December these had all changed to pupæ or died. The last adult appeared on December 27. In 1911 the larvæ were not very abundant after the first week in October, and the last ones were observed in Los Angeles County on November 21.

NUMBER OF GENERATIONS.

In the section of the State in which this insect was under observation, the first spring generation may commence as early as January 10 and probably egg-laying by overwintering adults continues for a considerable time. As the period of oviposition is quite extended the different broods tend to overlap; still in midsummer there are certain periods when the majority of thrips present may be adults or larvæ. Up to April 1 there is probably one small full generation occupying about 56 days. During April and May a second generation will develop; then during the four months of June, July, August, and September there is one full generation for each month. For the rest of the period of the breeding activity we have probably a partial brood that extends over 68 to 73 days.

Thus during the year this insect has a small generation in both the early spring and late fall and five full generations during the rest of the time, or seven generations a year.

SEASONAL HISTORY IN THE IMPERIAL VALLEY.

The observations on the life cycle of this insect for Imperial Valley were conducted by Mr. V. L. Wildermuth at El Centro, Cal., in 1910.

EGG PERIOD.

Mr. Wildermuth confined adults in vials with fresh sprigs of alfalfa and kept the foliage fresh by wrapping the stems in moist cotton until the larvæ hatched from the eggs. While many eggs were secured by this method, large numbers died before hatching, as the foliage became too dry, but, as shown in Table XI, the egg stage varied from four days in a single case to five days in a lot of 20 eggs laid the last day of August. The length of the egg stage at that locality was only one-third as great as that observed by the writer in Los Angeles County, but this is due in a large measure to the high temperature of the Imperial Valley.

TABLE XI.—*Length of incubation of the eggs of the bean thrips, El Centro, Cal., 1910.*

Date of oviposition.	Number laid.	Eggs hatched.		Length of stage.	Average mean temperature.
		Date.	Number.		
				Days.	°*F.*
July 27	2	Aug. 1	2	4½	(1)
Aug. 11	(2)	Aug. 15	1	4	[3]87.1
Aug. 31	(2)	Sept. 6	20	5	[3]88.7

[1] Records missing. [2] Many. [3] At Brawley.

LARVAL PERIOD.

The active feeding larva molts once before its final molt to the prepupal stage. This occurs in from one and one-half to two days after it hatches from the egg. The larva becomes full grown and changes to the prepupa in from four and one-half to five days. As might be expected from the great difference in the incubation period of the egg, the larval period in the Imperial Valley, as observed by Mr. Wildermuth, is much shorter than at Compton. These data are given in Table XII.

TABLE XII.—*Length of larval stage of the bean thrips at El Centro, Cal., during 1910.*

Exp. No.	Eggs hatched.		Molted.		Changed to prepupa.		Length.	Average mean temperature.
	Date.	Number.	Date.	Number.	Date.	Number.		
							Days.	°*F.*
1	Aug. 15	1	Aug. 16	1	Aug. 19	1	4½	85.8
2	Aug. 18	3	Aug. 19	1	Aug. 22	1	4½	(1)
3	Aug. 26	1	Aug. 28	1	Aug. 31	1	5½	91.9
4	Sept. 1	1	Sept. 3	1	Sept. 5	1	4	89.7
5	Sept. 22	1	Sept. 24	1	Sept. 27	1	5	81.8
	Total	7		5		5		

[1] Records missing.

PREPUPAL AND PUPAL PERIODS.

Unfortunately Mr. Wildermuth's records give a very small amount of data on the length of the prepupal and pupal periods, but in the six examples observed (see Table XIII) the stages varied from 2 to 3 days. While the writer was studying the greenhouse thrips the prepupal stage was often observed to last only a few hours, and this same condition probably occurs with the present species in the high temperature of the Imperial Valley.

TABLE XIII.—*Length of prepupal and pupal stages, El Centro, Cal., 1910.*

Exp. No.	Date changed to prepupa.	Date adult emerged.	Length of period.	Average mean temperature.
			Days.	° *F.*
1	Aug. 19	Aug. 21	2½–3	(1)
2	Aug. 22	Aug. 24	2	(1)
3	Sept. 6	Sept. 8	2–2½	[2] 84.9
4	Sept. 4	Sept. 8	3	[2] 85.1
5	Sept. 7	Sept. 9	2	[2] 87.0
6	Sept. 27	Sept. 29	2½	(1)

[1] Records missing. [2] Temperature at Brawley, U. S. Weather Bureau.

In the Imperial Valley the egg stage is from 4½ to 5 days, the larval stage from 4 to 5 days, and the prepupal and pupal stages from 2 to 3 days, making the total life cycle only 10 to 12½ days during the extreme summer temperature.

The eggs were deposited within 2 days from the time the adult females emerged, so that a new generation might occur every 14 days in midsummer. If the insect emerges from hibernation in the Imperial Valley at the same time as in Compton, there will undoubtedly be 1 generation in the early spring occupying 30 to 40 days, and then 2 generations a month for 5 or 6 months and 1 longer generation in the fall, or 12 to 14 generations a year. Indeed, with such rapid multiplication it is not strange that crops in the late fall become seriously infested.

SEASONAL HISTORY AT TEMPE, ARIZ.

Mr. Wildermuth during October and November, 1911, made some observations on the life cycle of this thrips at Tempe. These gave a life cycle of very nearly the same duration as in the Imperial Valley in the warm weather, but in November the cycle was lengthened considerably. He found that specimens collected as larvæ on October 30 did not emerge as adults until December 1. This shows the same effect of cooler weather on this insect that the writer observed at Compton, Cal.

Taking the results of Mr. Wildermuth's and the writer's observations on the bean thrips, there is a minimum life cycle of 10 days where the average mean temperature is about 88.75° F., and a maximum of about 73 days with an average mean temperature of about 53.58° F.

HIBERNATION.

This insect hibernates as an adult only, through most of its distribution at least. It may be that in the more southern portions of its range it breeds continuously throughout the year, but our observations in these localities mentioned have failed to show it.

In the section around Compton, Cal., the adults were found to hibernate in small numbers on the underside of leaves of nasturtium, sugar beets, wild heliotrope, and other plants. They were also found hiberating in some numbers in dead leaves and rubbish. When disturbed they were sluggish and made little effort to escape.

Mr. P. R. Jones (in litt.) says that around Lindsay, Cal., the adults hibernate in numbers in the navel end of the Washington navel orange. He also stated that in midwinter he had taken this thrips along creek beds hibernating on the underside of leaves of wild raspberry and blackberry which were still on the plants.

NOTES ON OCCURRENCE.

Apparently the different methods of cultivation bear strongly on the abundance of these insects and consequent injury they may cause to a crop. In Los Angeles County, where clean cultivation is not strictly followed out, it begins to breed in the spring on the wild food plants and increases more and more until in August it has reached enormous numbers. Before this the native plants are, many of them, either matured or destroyed by the thrips, and as a result it spreads more and more to the cultivated crops and trees that serve as hosts. During some years this occurs late in the season and very little real damage results, but if this insect should begin the year in fairly large numbers and under favorable conditions, great damage may result.

In Ventura County, in October, 1910, the author made a careful examination of the entire bean-growing section and found that the bean thrips occurred in extremely small numbers on the little vegetation remaining. At the same time it was extremely abundant around Compton. This condition seemed to be a direct result of the practice of the growers in Ventura of thoroughly plowing and cultivating the fields within a short time after the beans are harvested and keeping them in perfect condition until the next crop is planted. This advantage is increased because there is very little waste space where weeds can grow up. Our investigations during the past two years have shown that this insect is not abundant on cultivated crops in the spring or early summer, but that after this period it increases more and more, and in certain years injures them so severely as to cause much loss.

NATURAL CONTROL.

RAINS.

One of the largest factors in the destruction of thrips in some localities is the prevalence of hard, dashing rains. The author, while working in Florida with the greenhouse thrips, once observed

that crotons, which in the greenhouse were infested with thousands of thrips and which in June were placed outside and subjected to the Florida summer rains, when examined in September were so free from this insect that it was almost impossible to find specimens.

California, with its long dry season, does not obtain the same benefit, but even there the rains may reduce attacks of the bean thrips to some extent. On February 7, 1911, the writer observed a pea field that had from 5 to 8 adults on every plant. After this date there was a severe rain of several days' duration, and when the field was again examined, on April 1, it was almost impossible to find the thrips. Mr. Graf, writing from Puente, Cal., on October 6, 1911, noted that the larvæ were much scarcer than a week earlier, probably owing to a rainfall of one-half inch. Mr. Wildermuth, at Tempe, Ariz., wrote on October 5, 1911:

> A search in the patch of alfalfa back of the office, where thrips had been very numerous for several weeks, failed to reveal very many thrips to-day. The heavy rain of yesterday and last night was probably responsible for washing them off.

In California, then, late rains in the spring may greatly diminish the numbers of this insect, or early rains in the fall destroy many that otherwise would enter hibernation.

FIG. 10.—The bean thrips: Prepupæ parasitized by *Thripoctenus russelli*. Much enlarged. (Author's illustration.)

NATURAL ENEMIES.

A great deal of attention has been given to the subject of natural enemies and some information obtained on this important feature of insect control.

In the fall of 1910 the larva of this thrips was discovered to be parasitized (see fig. 10) by a minute hymenopteron. This was described by Mr. J. C. Crawford as *Thripoctenus russelli* (see fig. 11). During 1911 this parasite was observed to work extensively in Los Angeles County on the bean thrips and seemed to destroy large numbers. Some collections of thrips larvæ gave as high as 70 per cent killed by the parasite. For a full account of this parasite the reader is referred to Technical Series 23, Part II, Bureau of Entomology, United States Department of Agriculture.

During 1911 the larva of a green lacewing fly (*Chrysopa californica* Coq.) was commonly observed feeding on the larva of this thrips. As this insect was observed so engaged in several localities in Los Angeles County, and in noticeable numbers, it probably kills a large number of thrips.

The larva of a syrphid fly (*Sphærophoria sulphuripes* Thomson) was also observed on numerous occasions feeding on the larva of

the bean thrips, and in confinement larvæ were observed to kill and eat large numbers of the host.

The young of *Triphleps insidiosus* Say were noticed on many occasions feeding on the young of this thrips and undoubtedly aid in reducing its numbers.

The larvæ and adults of *Hippodamia convergens* Guér were frequently collected on plants infested with thrips, where they were busily engaged in feasting on the tender larvæ of the bean thrips.

On several occasions larvæ of a predaceous thrips, probably *Æolothrips fasciatus* L., when collected were feeding on the larvæ of the bean thrips.

FIG. 11.—A hymenopterous parasite, *Thripoctenus russelli:* Adult. Greatly enlarged. (Author's illustration.)

Mr. P. R. Jones informed the writer that at Lindsay, Cal., in 1910, he found a "nematode parasite working in the full-grown larvæ of the bean thrips."

A curious circumstance in connection with the observations made on the natural enemies of the bean thrips was the fact that in all of the predaceous forms noted the alimentary tract became bright red, undoubtedly due to the crimson or reddish pigmentation of the host.

ARTIFICIAL CONTROL.

CULTURAL METHODS.

In the case of crops planted over large areas and difficult or impossible to spray, such as beans, alfalfa, or cotton, cultural methods offer the most hope as a remedy for the bean thrips. Where this insect threatens injury it is recommended that these methods be used so far as possible. It is very important that the crops be given

careful, clean cultivation, so that all weeds may be kept down in the fields at all times, including the spring and fall. These same weeds, especially the different species of wild lettuce, should be carefully destroyed along the edges of all fields and fence corners and along the roads and railroad tracks. Cotton and beans should not follow in old alfalfa fields if the latter were badly infested with the bean thrips, and fields of these crops should be removed as far as possible from the alfalfa fields. They should also be planted as early as is consistent with good farming and encouraged by frequent cultivations and fertilizers where necessary to produce an early crop so as to escape the ravages of the bean thrips in the late summer.

As this insect feeds on such a variety of plants it is hardly possible that rotation of crops would aid materially in its control unless some crop could be found that is quite immune.

Where it is injuring alfalfa Mr. Wildermuth recommends disking and thorough renovation of the fields and good irrigation in order to give the plants as much chance as possible to make a quick growth.

SPRAYING.

The control of this thrips by spraying is impracticable for a crop such as alfalfa or cotton, and because of the low trailing vines of the bean will probably be successful with this plant only when the vines can be easily reached from the underside. In case injury to fruit trees is threatened it can be controlled by using the spray so successful against the pear thrips. This is a solution of $2\frac{3}{4}$ per cent nicotine, diluted at the rate of 1 part to 60 parts of water in a 6 per cent distillate-oil emulsion.[1]

The distillate-oil stock emulsion, according to the formula of Foster and Jones, is made as follows:

Hot water	gallons	12
Fish-oil or whale-oil soap	pounds	30
Distillate-oil (raw) 30° to 34° Baumé	gallons	20

Have the water boiling hot when put into the spray tank and add the soap immediately while the agitator is running at a good speed. When the soap is all thoroughly dissolved pour in the oil slowly, keeping the mixture well agitated while the oil is going into the tank. When all of the oil is in and well mixed, pump out through the nozzles at good pressure (not less than 175 pounds) into storage tanks.

No one should attempt to make this stock emulsion without a power spraying machine, as thorough agitation and high pressure are important requisites. Also, care should be used in having measurements reasonably exact, the water boiling hot, and the soap thoroughly dissolved before any oil is put in. This stock solution contains approximately 55 per cent oil, and to make a 3 per cent emulsion use $5\frac{1}{2}$ gallons of this stock in each 100-gallon tank.

[1] For a full account of this spray as used against the pear thrips, see Circular 131, Bureau of Entomology, U. S. Dept. of Agriculture, pp. 8–9.

A simpler formula and one that possibly will act quite as well on this insect, where it is exposed on the foliage, and one that will offer no chance for the burning of the foliage, has given good results in the destruction of *Heliothrips rubrocinctus* Giard in Florida. Mr. Edward Simmonds, of the Bureau of Plant Industry, advised the writer that a solution composed of 1 gallon of blackleaf tobacco extract, 1 pound of whale-oil soap, and 50 gallons of water gave excellent results in treating trees infested by this insect. This formula seems a little strong to the writer and he would recommend using the blackleaf at the rate of 1 part to 60 parts of water. In the place of this, a 40 per cent solution of nicotine can be substituted at the rate of 1 part to from 1,000 to 2,000 parts of water.

DISTRIBUTING THE PARASITE.

Possibly the parasite of this insect can be artificially distributed with good results to sections infested by this thrips where the parasite does not occur. For directions and methods of shipping this parasite, the reader is referred to Technical Series 23, Part II, Bureau of Entomology, U. S. Department of Agriculture, page 51.

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